ME 516: Macroscale Heat Transfer

Course description: Principles of heat transfer at the macroscale including conduction, convection, radiation, and multi-mode problems utilizing analytical and numerical techniques.

Number of credits: 3

Prerequisites by course: Introductory heat transfer, thermodynamics, and fluid mechanics courses;

Course objectives:
1) Experience utilizing simple hand calculations to design a heat transfer simulation.
2) Experience deriving the governing differential equations to general engineering heat transfer problems.
3) Experience developing analytical and numerical solutions to the governing differential equations.

Course resources
- ✓ Text: G.F. Nellis and S.A. Klein, *Heat Transfer*, Cambridge University Press, 1st ed. (2008). (not required Parallel Book)**:** R.F. Barron and G.F. Nellis, *Cryogenic Heat Transfer*, CRC Press, 2nd ed. (2016), download from WSU libraries: https://searchit.libraries.wsu.edu/permalink/f/1j6uprt/CP71249439880001451
- ✓ Software: We will use EES and open source Python software whenever possible.
- ✓ Website: All course materials will be posted on Blackboard, including Lesson Forums: https://learn.wsu.edu; additionally, information will be posted on the https://hydrogen.wsu.edu website

- ✓ **Reasonable Accommodation** (the nature of the particular course determines which one applies):

  Pullman Campus. Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please either visit or call the Access Center (Washington Building 217; 509-335-3417) to schedule an appointment with an Access Advisor. All accommodations MUST be approved through the Access Center.

- ✓ **Academic Integrity** WSU expects all students to behave in a manner consistent with its high standards of scholarship and conduct. Students are expected to uphold these standards both on and off campus and acknowledge the university's authority to take disciplinary action. The Standards of Conduct for Students can be found at http://conduct.wsu.edu.

- ✓ **WSU Safety** WSU is committed to maintaining a safe environment for its faculty, staff, and students. Safety is the responsibility of every member of the campus community and individuals should know the appropriate actions to take when an emergency arises. In support of our commitment to the safety of the campus community the University has developed a Campus Safety Plan (http://safetyplan.wsu.edu). It is highly recommended that you visit this web site as well as the University emergency management web site at http://oem.wsu.edu/ to become familiar with the information provided.

- ✓ **Classroom Safety** Classroom and campus safety are of paramount importance at Washington State University, and are the shared responsibility of the entire campus population. WSU urges students to follow the "Alert, Assess, Act" protocol for all types of emergencies. Remain ALERT (through direct observation or emergency notification), ASSESS your specific situation, and ACT in the most appropriate way to assure your own safety (and the safety of others if you are able).
  Please sign up for emergency alerts on your account at MyWSU. For more information on this subject, campus safety, and related topics, visit the WSU safety portal (https://faculty.wsu.edu/classroom-safety/).

Specifics for Fall 2019

MEETING TIME AND LOCATION: Lecture: Pullman- CARP 101 M,W,F 10:10-11 AM.

INSTRUCTOR: Dr. Jacob Leachman, Office: Sloan 217, Phone: 509-335-7711 (office), 208-816-0288 (cell) e-mail: jacob.leachman@wsu.edu **TA:** Not even in your wildest dreams…

COURSEWORK:
- ✓ Homework will be assigned weekly, including both quantitative and qualitative assignments.
- ✓ No credit is awarded for late assignments; your two lowest homework grades for the class will be dropped.

GRADING: Participation: 20%; 3 Exams: 30% Homework: 25%; Project: 25%. Distribution: 100–93 (A), 93–90 (A-), 90–87 (B+), 87–83 (B), 83–80 (B-), 80–77 (C+), 77–73 (C), 73–70 (C-), 70–60 (D), 60–0 (F), incomplete (I), integrity violation (X).

ME 516: Macroscale Heat Transfer

SCHEDULE:

Date		Day	Topics	Readings
8/19	Conduction	*Mon*	1. Class Organization, Introduction to Heat Transfer	1.1, 1.2
8/21		*Wed*	2. Analytical 1-D Conduction: Cartesian, Radial, & Spherical geometries	1.2, 1.3
8/23		*Fri*	3. Numerical 1-D Conduction I	1.4
8/26		*Mon*	4. Numerical 1-D Conduction II	1.5
8/28		*Wed*	5. Analytical extended surfaces	1.6, 1.7
8/30		*Fri*	6. Advanced extended surfaces	1.8, 1.9
9/2		*Mon*	**Labor Day – No Class**	
9/4		*Wed*	7. Analytical 2-D conduction: Shape Factors & Separation of Variables	2.1, 2.2
9/6		*Fri*	8. Analytical 2-D conduction: Separation of Variables and Superposition	2.3, 2.4
9/9		*Mon*	9. Numerical 2-D conduction	3.3, 3.5
9/11		*Wed*	10. Transient Lumped Capacitance: Analytical and Numerical Solution	3.1, 3.2
9/13		*Fri*	11. Analytical 1-D transients: Semi-Infinite and Separation of Variables	3.3, 3.5
9/16		*Mon*	12. Numerical 1-D transients: Euler through Runga-Kutta methods I	3.8
9/18		*Wed*	13. Numerical 1-D transients: Euler through Runga-Kutta methods II	
9/20		*Fri*	**Exam 1: Conduction HT**	
9/23	Project	*Mon*	14. Team and project formation	
9/25		*Wed*	15. Problem statement draft	
9/27		*Fri*	16. Problem statement review	
9/30		*Mon*	17. Solution development I	
10/2		*Wed*	18. Solution development II	
10/4		*Fri*	19. Solution development III	
10/7	Convection & Heat Exchangers	*Mon*	20. External flow boundary layer concepts	4.1-4.3
10/9		*Wed*	21. Solution to external flow problems	4.4-4.9
10/11		*Fri*	22. Internal flow concepts	5.1-5.2
10/14		*Mon*	23. Analytical solution to internal flows	5.3, 5.4
10/16		*Wed*	24. Numerical solution to internal flows	5.5
10/18		*Fri*	25. Numerical solution to internal flows	5.5
10/21		*Mon*	26. Natural Convection	6.1-6.4
10/23		*Wed*	27. Boiling and Condensation	7.1-7.5
10/25		*Fri*	28. 2-phase Flow	
10/28		*Mon*	29. Heat Exchangers: Analytical LMTD vs. ε-NTU	8.1-8.3
10/30		*Wed*	30. Heat Exchangers: Pinch points and phase change	8.4, 8.5
11/1		*Fri*	31. Heat Exchangers: Numerical parallel and counter-flow	8.6, 8.7
11/4		*Mon*	32. Heat Exchangers: Numerical cross-flow	8.8, 8.9
11/6		*Wed*	33. Heat Exchangers: Regenerators I	8.10
11/8		*Fri*	**Exam 2: Convection HT**	
11/11	Radiation	*Mon*	**Veteran's Day – No Class**	
11/13		*Wed*	34. Radiation exchange between black surfaces	10.1-10.2
11/15		*Fri*	35. Radiation exchange view factors	10.3
11/18		*Mon*	36. Radiation exchange between real surfaces I	10.4
11/20		*Wed*	37. Radiation exchange between real surfaces II	10.5
11/22		*Fri*	38. Numerical estimation of view factors I	10.7
			Thanksgiving Break – No Class	
12/2		*Mon*	39. Numerical, multi-modal heat transfer problems I	10.6
12/4		*Wed*	40. Numerical, multi-modal heat transfer problems II	
12/6		*Fri*	**Exam 3: Radiation HT**	
			Final Project Presentations	